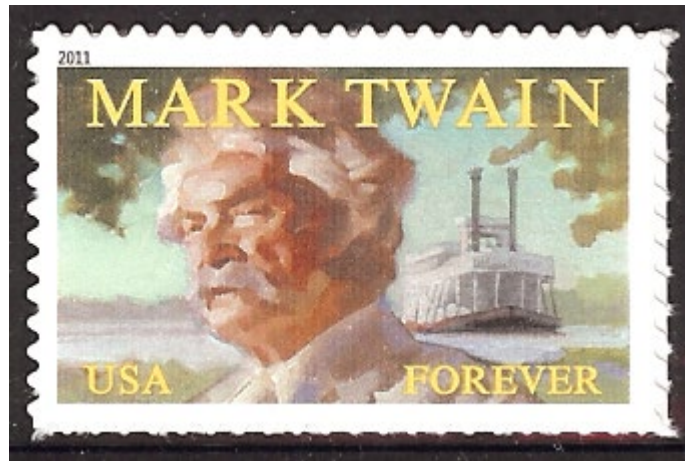


Garry Toth

GeoPhilately Workshop – 19 March 2022

An Introduction to Meteorology and Space Weather in Philately

Part 1 – Meteorology (includes Weather and Climate)



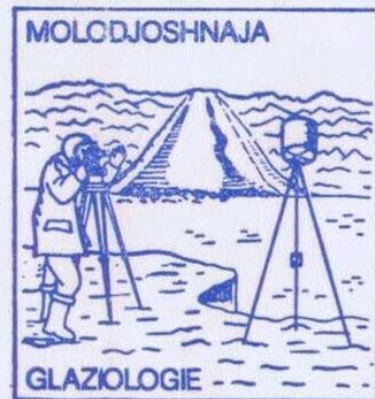
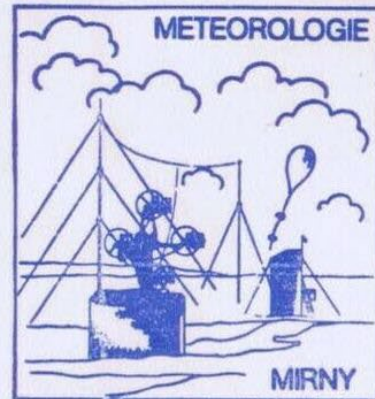
Climate is what we expect, weather
is what we get.

MARK TWAIN

Geophysics / Earth
Sciences include
meteorology

Teilnehmergruppe an der
25. Sowjetischen Antarktisexpedition

1959 - 20 JAHRE DDR-ANTARKTISFORSCHUNG - 1979



AKADEMIE DER WISSENSCHAFTEN DER
DEUTSCHEN DEMOKRATISCHEN REPUBLIK

P. Korsch
H. Wand
H. Schäfer
H. G. Fink
H. K.



F. Tarnbeil
Sofia St. 1
DDR-50 Erfurt

International Cooperation – the IPYs (International Polar Years)

1st IPY – 1882-1883 – 100th anniversary



2nd IPY – 1932-1933



3rd and 4th IPYs (3rd IPY is the **IGY** – the International Geophysical Year)



3rd IPY – 1957-1958

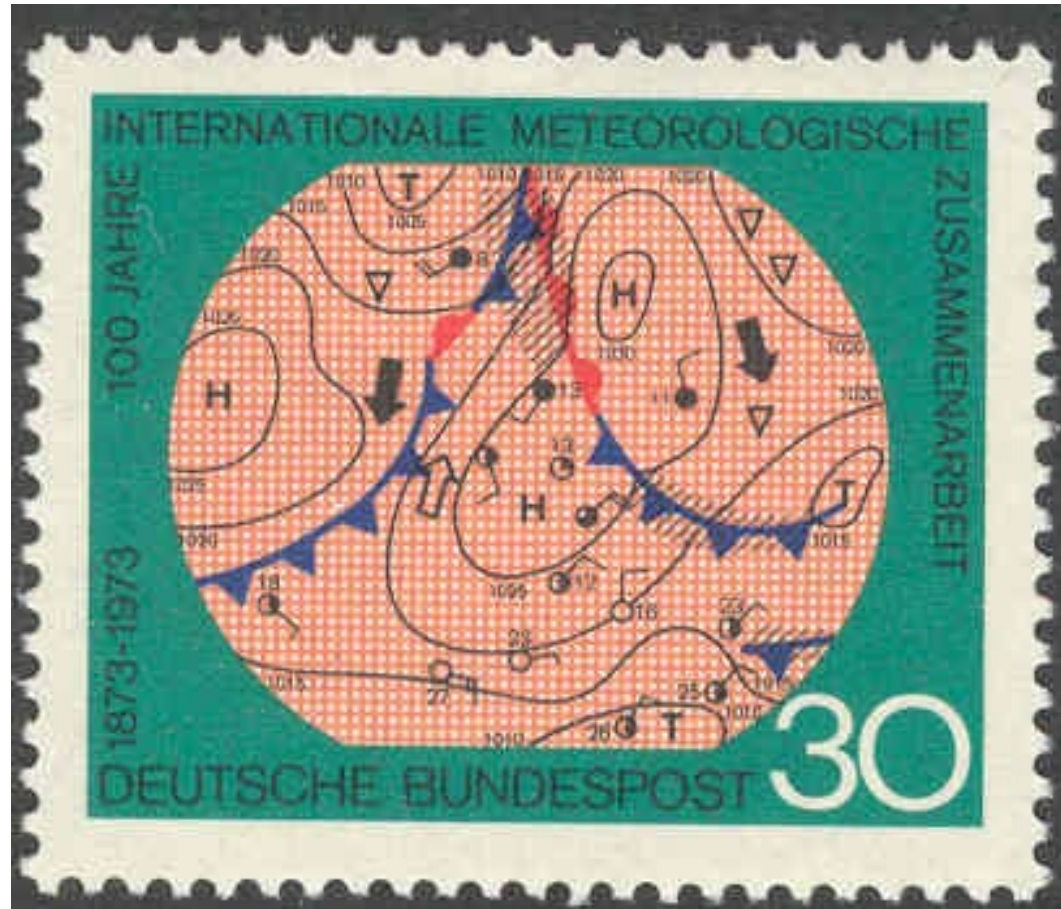


4th IPY – 2007-2008



World Meteorological Organization (WMO) (originally IMO – International Meteorological Organization)

100th anniversary IMO/WMO, in 1973

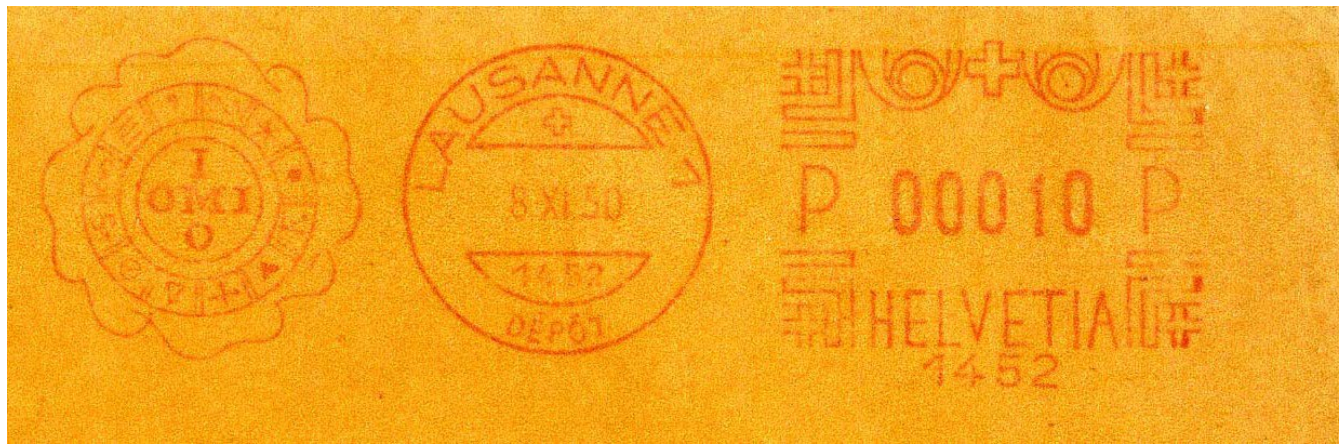


World Meteorological Day – each 23 March since 1961



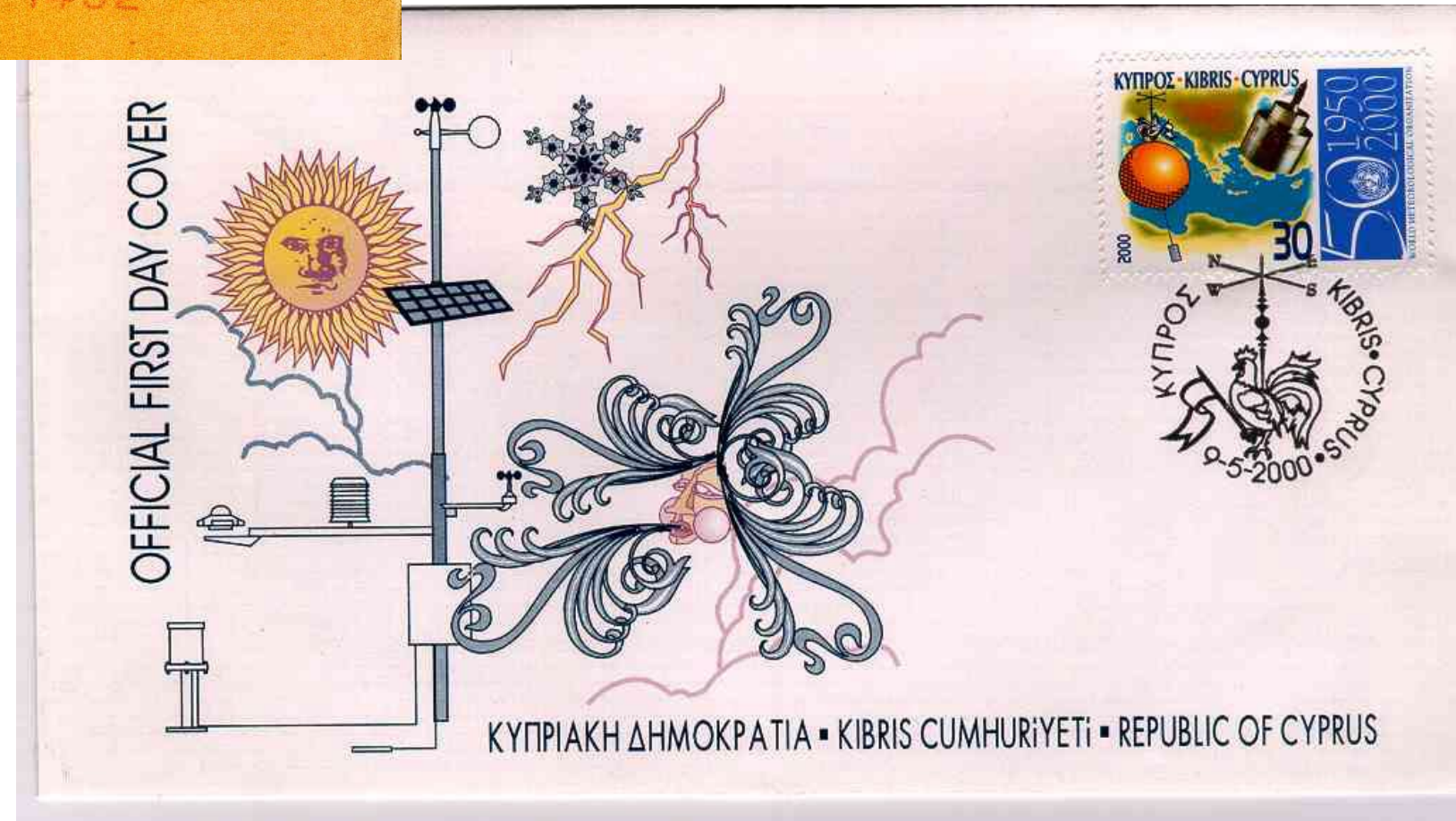


The IMO became the WMO (the World Meteorological Organization) in 1950



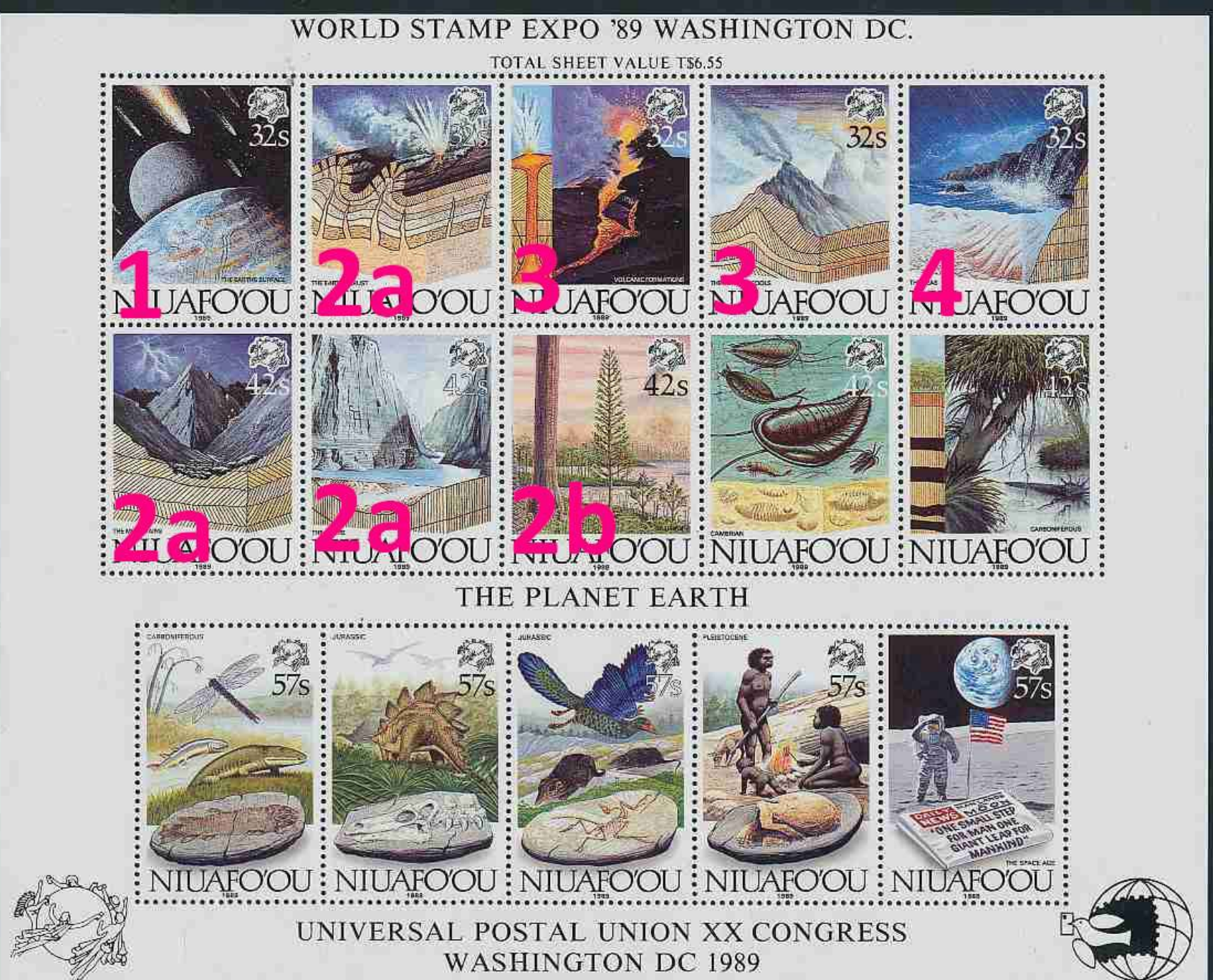
WMO 50th Anniversary (in 2000)

WMO logo



Some elements of geophysics related to meteorology

1. Asteroid/Meteorite strike
2. Continental Drift
3. Vulcanism
4. Oceans



**Alvarez theory - ~10 km
diameter meteorite
(asteroid) impact**

65 million years ago

Changed climate

Chicxulub crater (Yucatan)

**Alvarez (father & son) –
iridium layer at Cretaceous-
Tertiary (K-T) boundary**

→ K-T extinction event



Continental Drift & Climate Change



Wegener – **meteorologist** who developed continental drift theory



The disastrous Scott South Pole expedition collected fossilized *Glossopteris* leaves, recovered after their bodies were found. From a warm and wet **climate**, they were one piece of evidence supporting the idea of continental drift



Major Volcanic Eruptions in Recorded History

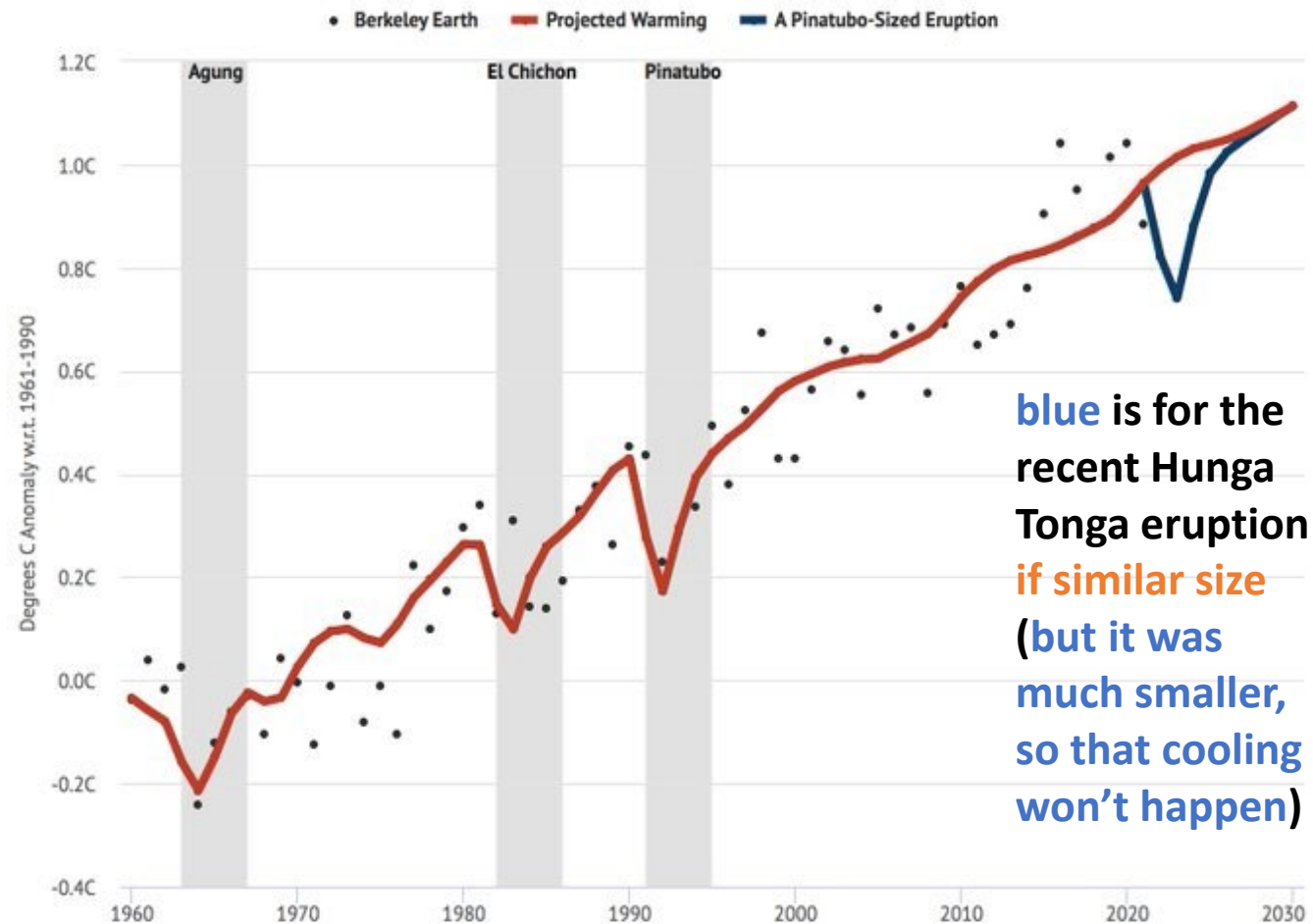
Tambora's eruption in 1815 was followed in 1816 by what was called in some areas a "year without summer". Krakatoa's eruption in 1883 also had significant climate effects.



Recent Large Eruptions

Climate impact ($\sim 0.2^{\circ}\text{C}$ of cooling for ~ 3 yr) of Pinatubo, Agung and El Chichón (1982) – dotted observations and red model forecasts

Climate impact of Pinatubo-sized eruption in 2022



Agung
(1963)



Pinatubo (1992)



Volcanoes and Aviation

Eruption seen from ISS (Cleveland Volcano, Aleutians, 23 May 2006)

Volcanoes and
airplanes don't mix!



Two volcanoes that caused aviation problems and closed airspace

Mt. St. Helen's, Washington State (18 May 1980 eruption)



Eyjafjallajökull (Iceland, April 2010 eruption)

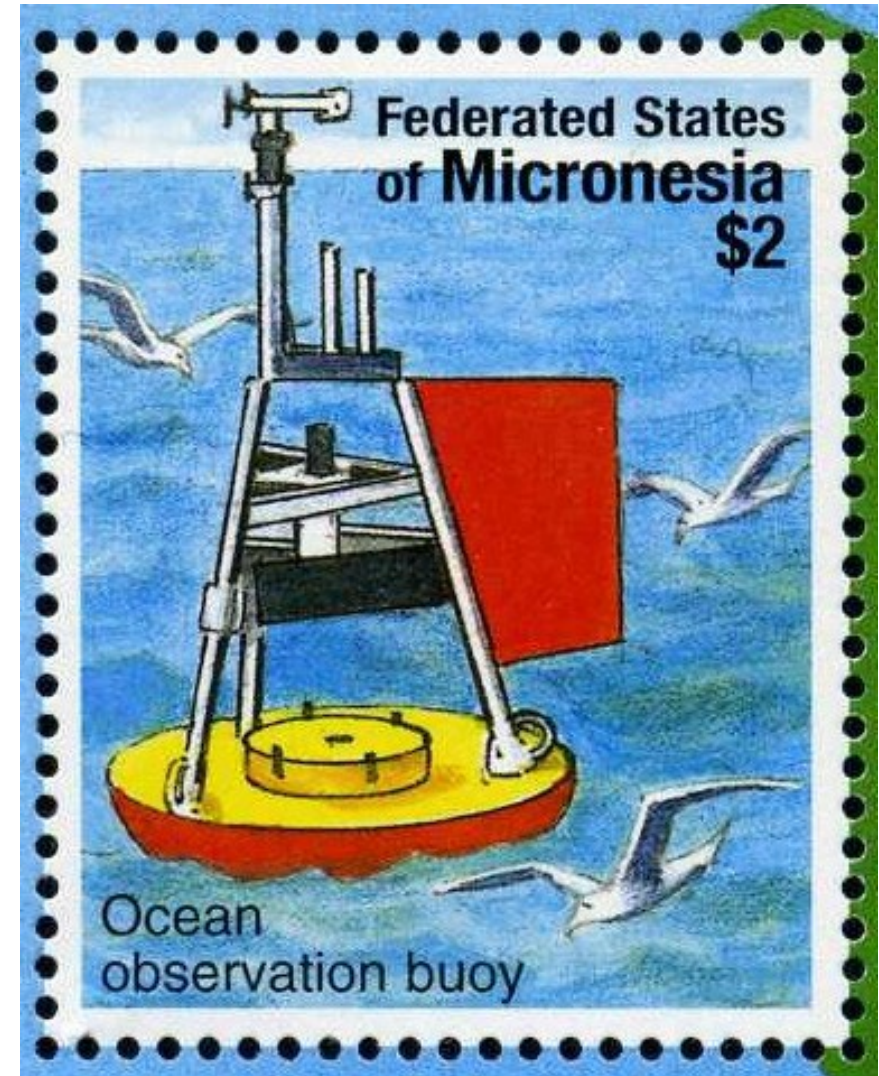


Ocean SST

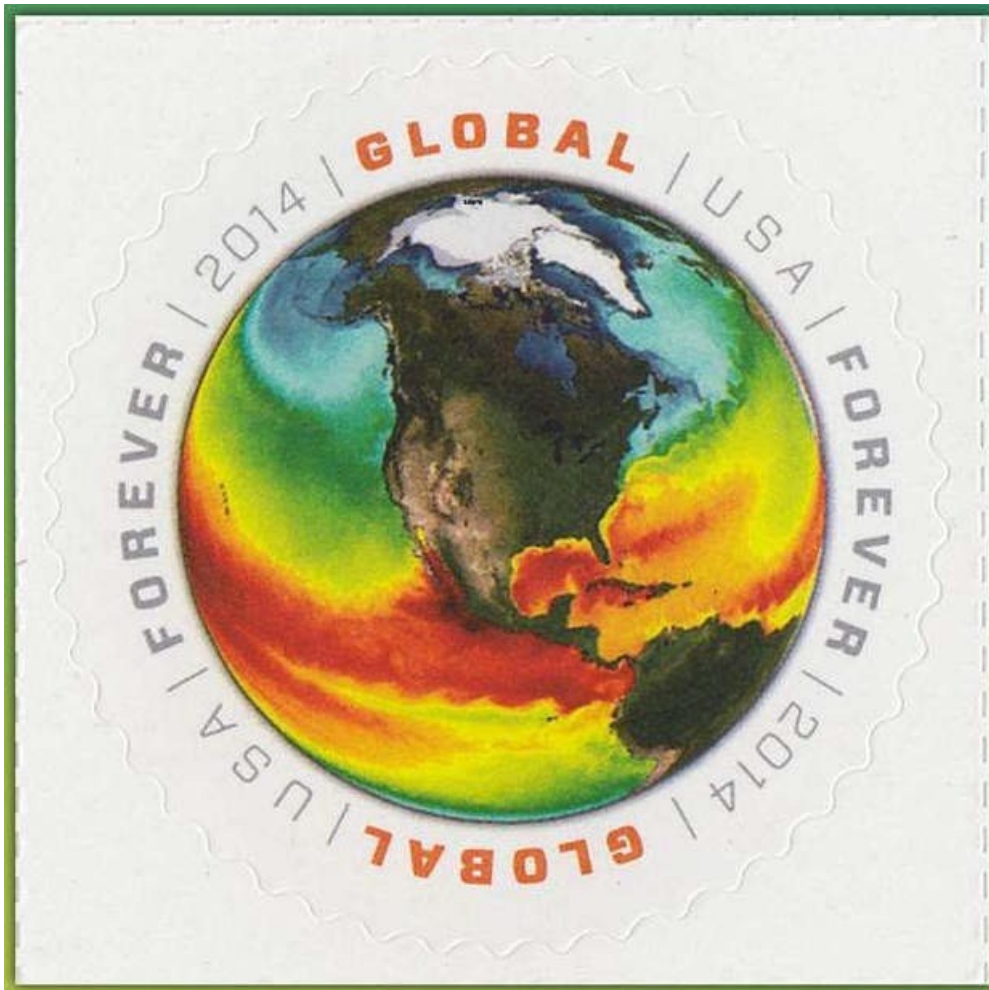
Satellite observations



Weather buoy observations



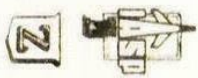
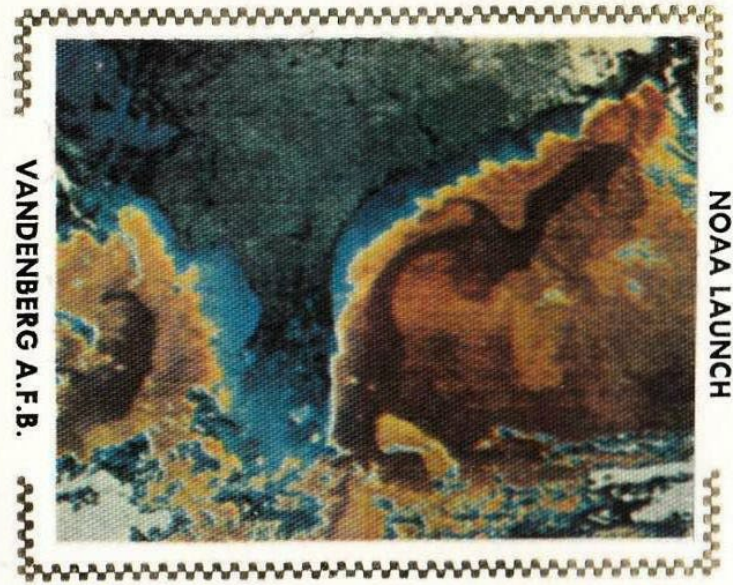
Sea Surface Temperatures (SSTs)



SST anomalies (in this map, with El Niño off Peru)



Warm
Gulf
Stream
(and Gulf
of Mexico
Loop
Current)
seen
from
space (by
NOAA-6)



THE GULF STREAM AND THE GULF OF MEXICO'S LOOP CURRENT APPEAR ORANGE IN A COLOR CODED INFRARED IMAGE FROM A NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) SATELLITE. LAUNCHED FROM VANDENBERG A.F.B. CALIFORNIA ON JUNE 27th, 1979.

16 — OFFICIAL I.A.S.P. SERIES



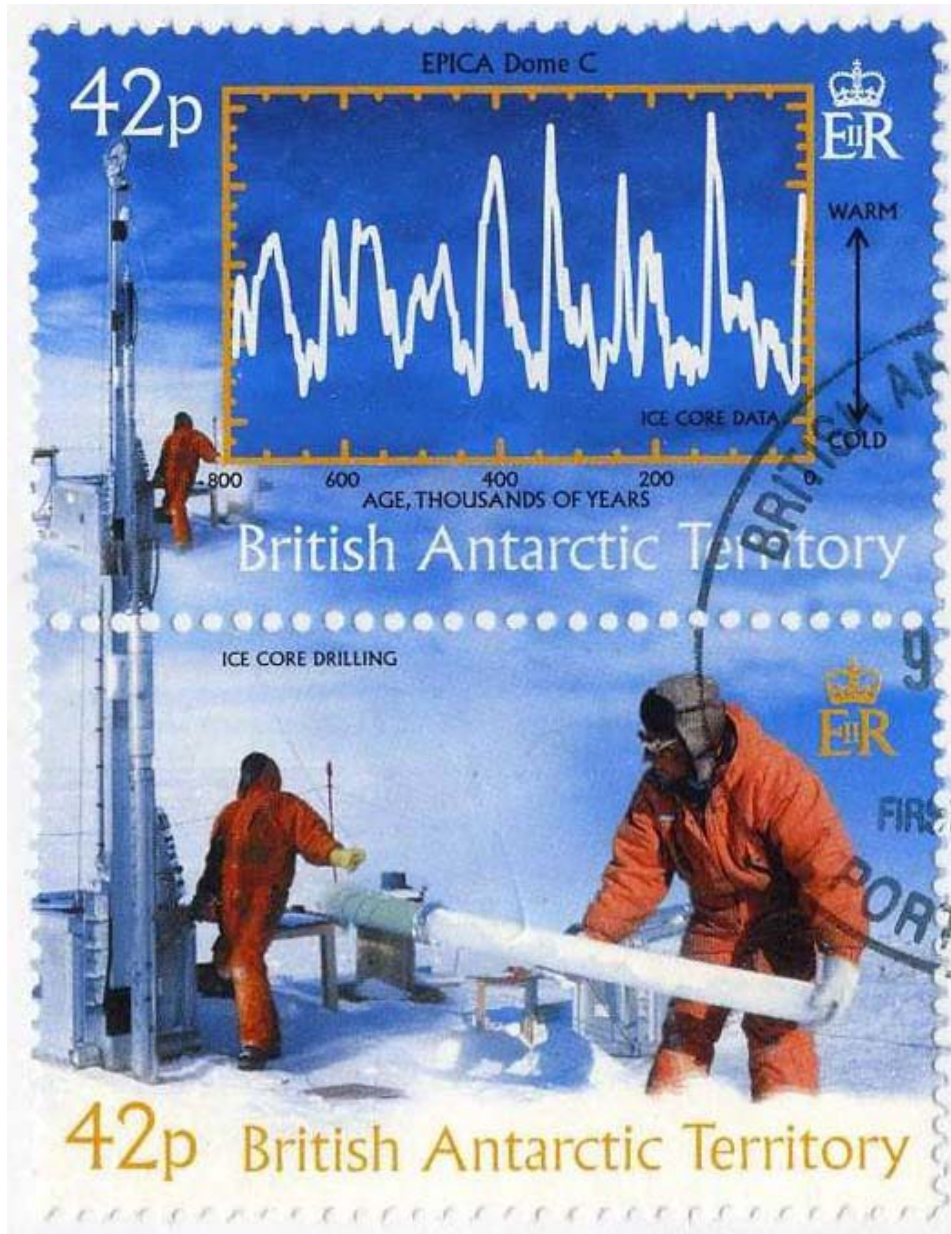
In 1769,
Benjamin
Franklin
published
the first
known
map of the
Gulf
Stream



FIG. 173. — FRANKLIN'S CHART OF THE GULF STREAM.

Glaciology and Ice Coring

Historical temperatures can be estimated from ice cores



Glaciology, Ice Coring and Snowflake



Ocean Floor Sediment Coring

Ocean sediment
“coring
for past
climate
changes”

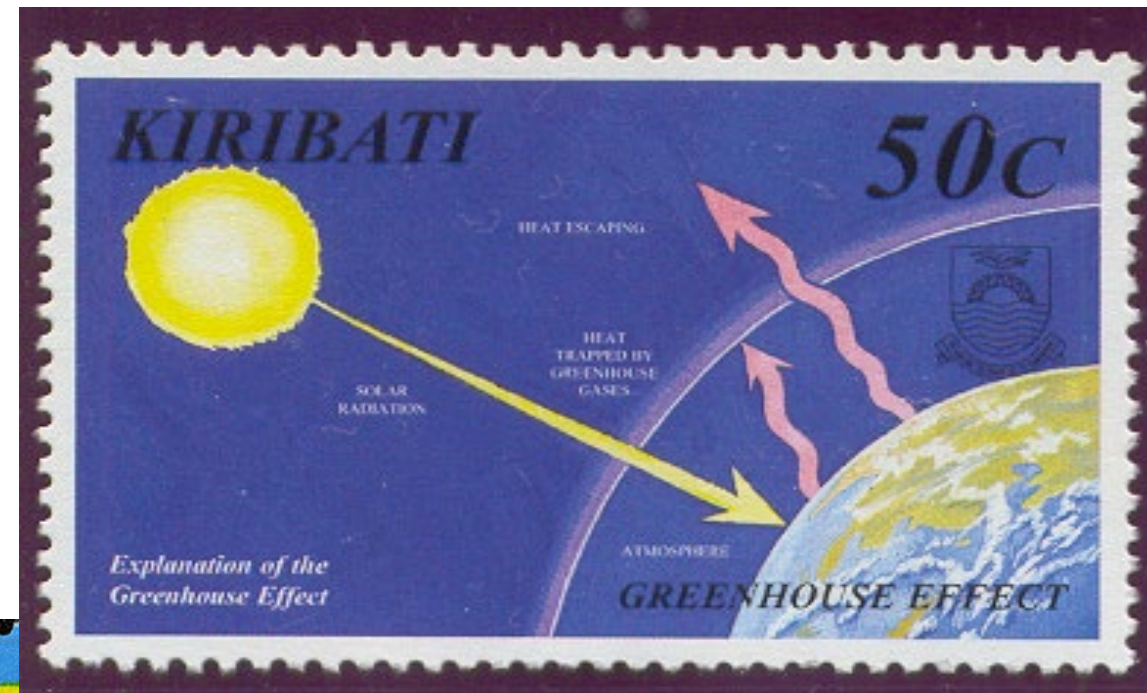


Ocean sediment coring
and continental drift



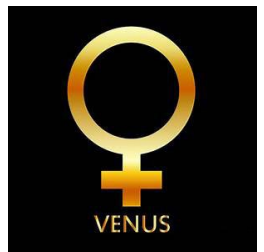
Global Warming and Climate Change

~1825 – Fourier - 1st to present the idea of the atmosphere as an “insulator” (the atmospheric “greenhouse effect”)



Atmosphere traps some outgoing L/W radiation. More greenhouse gases → more trapping → temperature rises

Venus – extreme greenhouse effect – surface temperature ~462° C



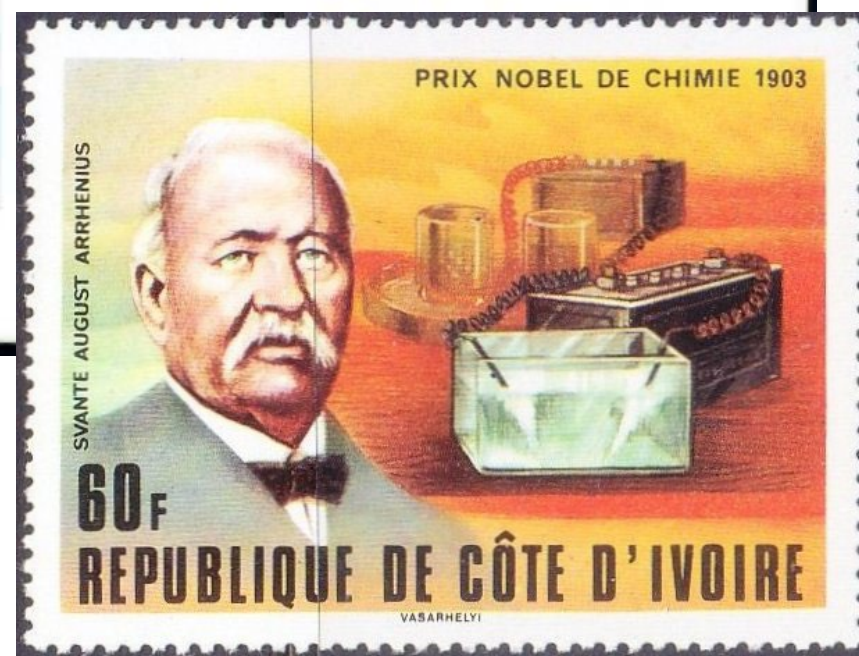
Fossil fuel burning increases **CO₂** in Earth's atmosphere



Global Warming

Forecast

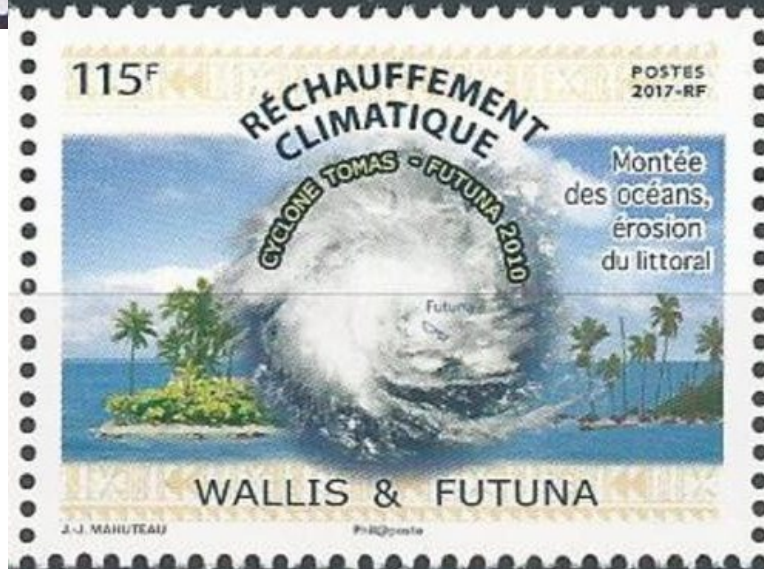
Observed



Arrhenius – 1896
– 1st forecast of
warming due to
CO2 release

Some Impacts of Global Warming and Climate Change

Sea level rise, flooding and coastal erosion



Heat waves



Drought



Wildfires (in forests, but also in built-up areas)





Health effects (e.g. due to heat waves, poor air quality, changing patterns of disease and migration of insects, severe weather, etc)

Estimated Deaths Attributed to Climate Change in the Year 2000, by Subregion*

Mortality per Million Population

- 0 - 2
- 2 - 4
- 4 - 70
- 70 - 120
- no data

*Change in climate compared to baseline 1961-1990 climate

Data Source:
McMichael, J.J., Campbell-Lendrum, D., Rowe, B., et al. Global Climate Change: In Comparative Quantification of Health Risks: Global and Regional Burden of Disease due to Selected Major Risk Factors. M. Ezzati, A.G. Rodgers, A. Murray, C.B. Goreau, World Health Organization, 2004

Maps produced by the Center for Sustainability and the Global Environment (CSGE)

Ozone

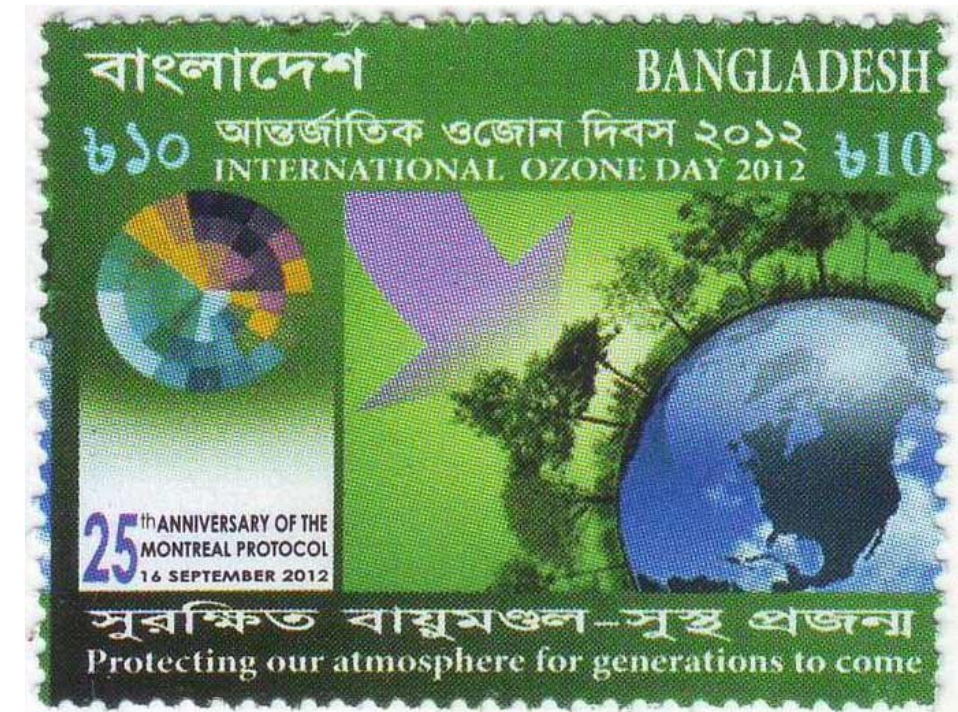
Antarctic ozone hole



Molina
and ozone
equation

Healing the hole –
1987 Montréal
Protocol – phase
out CFCs

Also, World Ozone
day, each year on
16 September



Ice Ages

16,000 BC - maximum glaciation
and minimum sea level

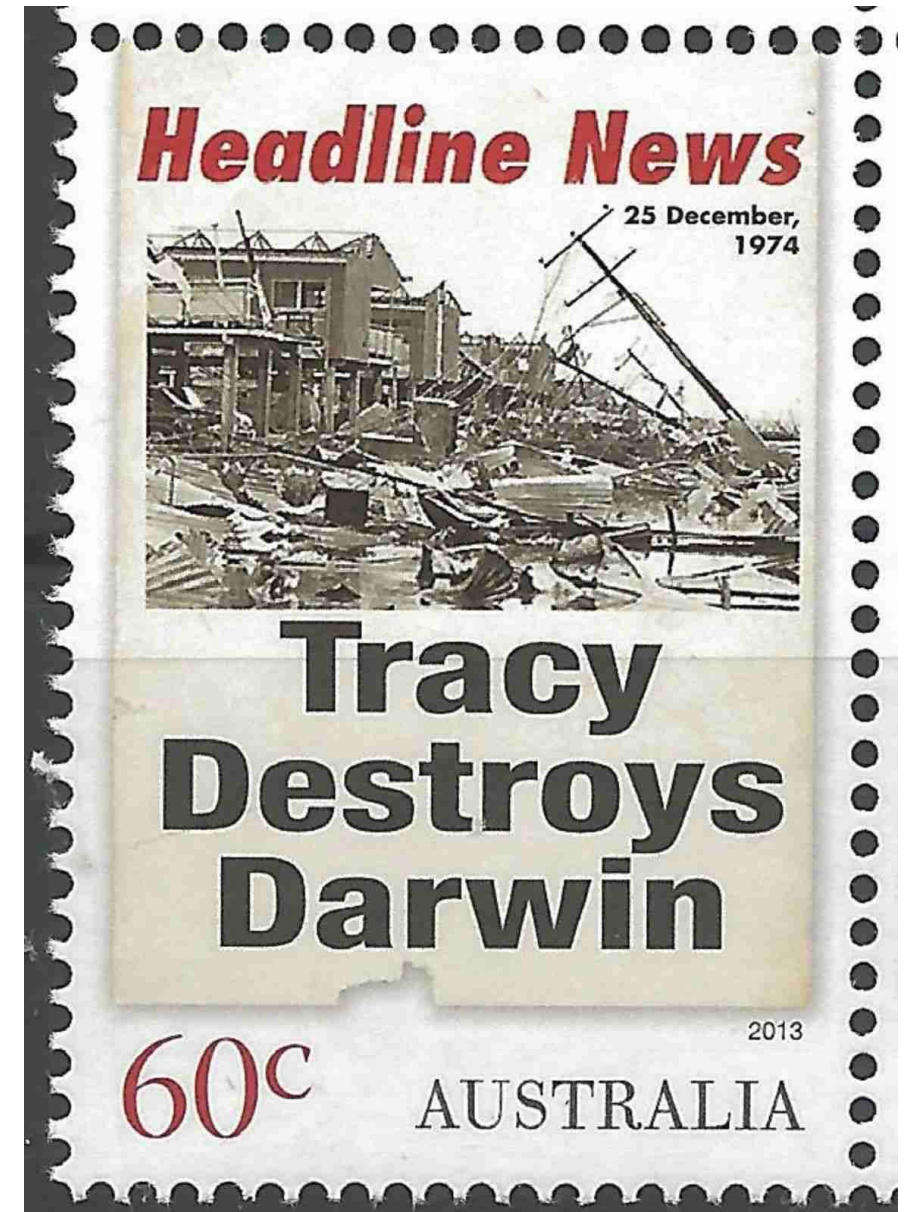


1930s – Milankovic – mathematical
relationships between **the cycles of the Ice
Ages** and changes in Earth's orbital
eccentricity, axial tilt and precession



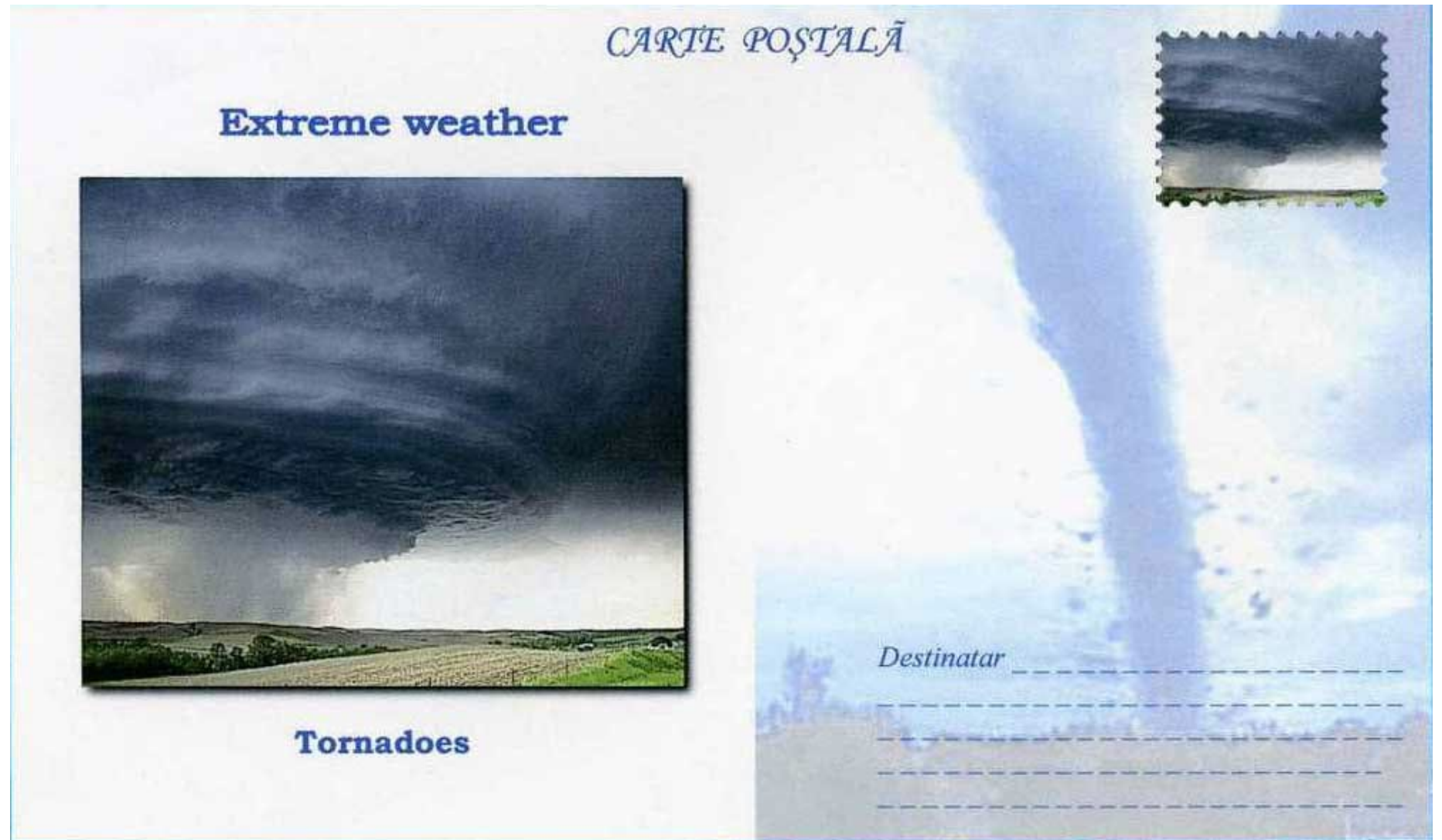
Some Storms 1

Hurricanes/Typhoons/Cyclones



Some Storms 2

Tornadoes



Windstorm

Some Storms 3



Blizzard (US Scott 292, year 1898)



Part 2 – Space Weather

- The effects of “storms” of solar energy and particles on Earth’s atmosphere, on its biology and technology, and on the near-Earth space environment
- “near Earth” – as far as the Moon
- Such effects also exist elsewhere in solar system (e.g. deep space, other planets)

The auroras symbolize space weather

Iceland Scott C17, year 1934



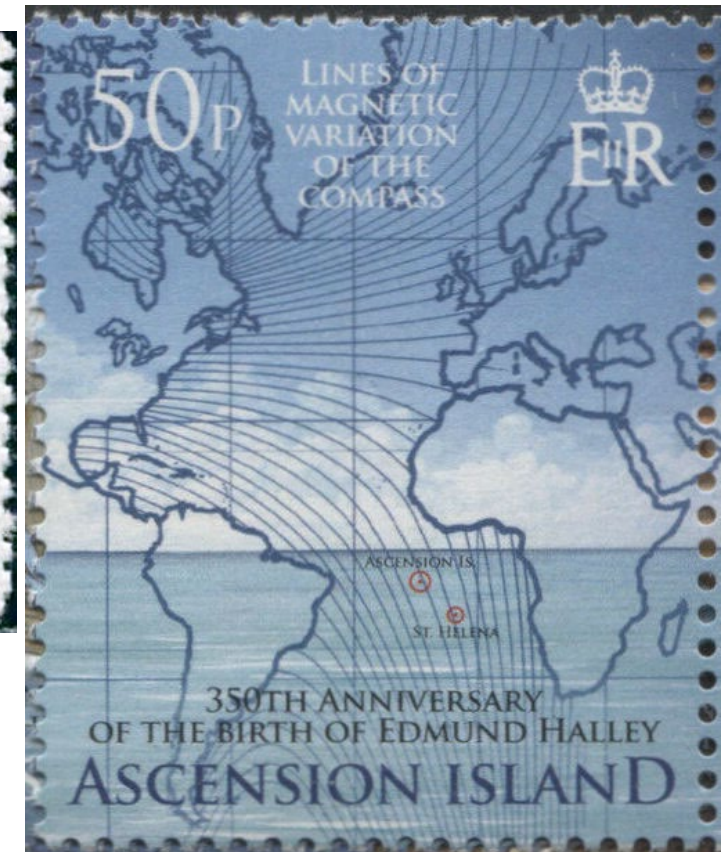
Antecedents 1 – Earth magnetism



An early Chinese compass (ca 400 BC) – magnetized iron spoon on bronze plate



Halley's map of lines of magnetic variation of the compass (1701)



Antecedents 2 - Auroras



Angels in the sky?



Spirits of the Dead in the sky, playing a ball game with a walrus head?

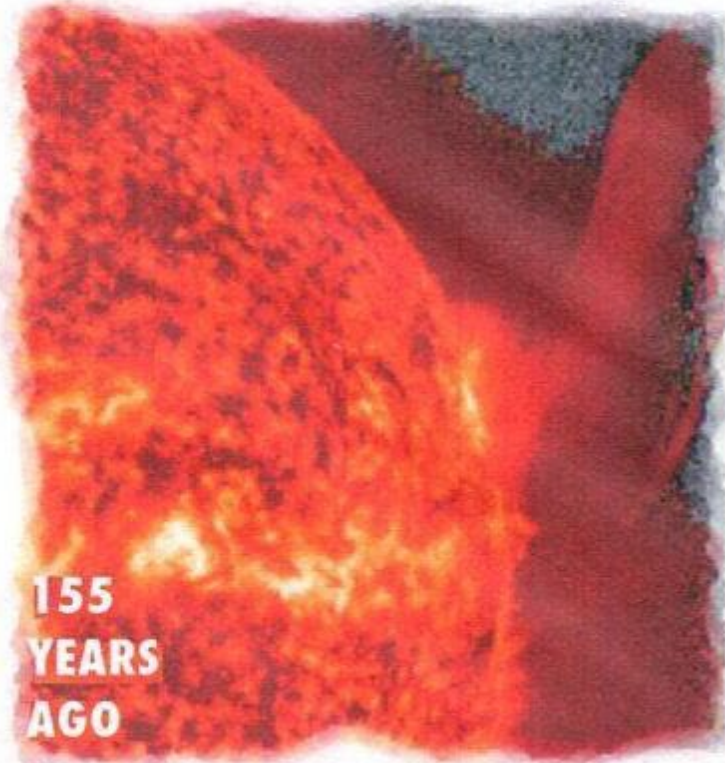


Von Humboldt -1805 – observed strong variations of the magnetic field in the presence of auroras → term “**Magnetischer Sturm**”. BUT was its origin terrestrial or external?

The Carrington Event

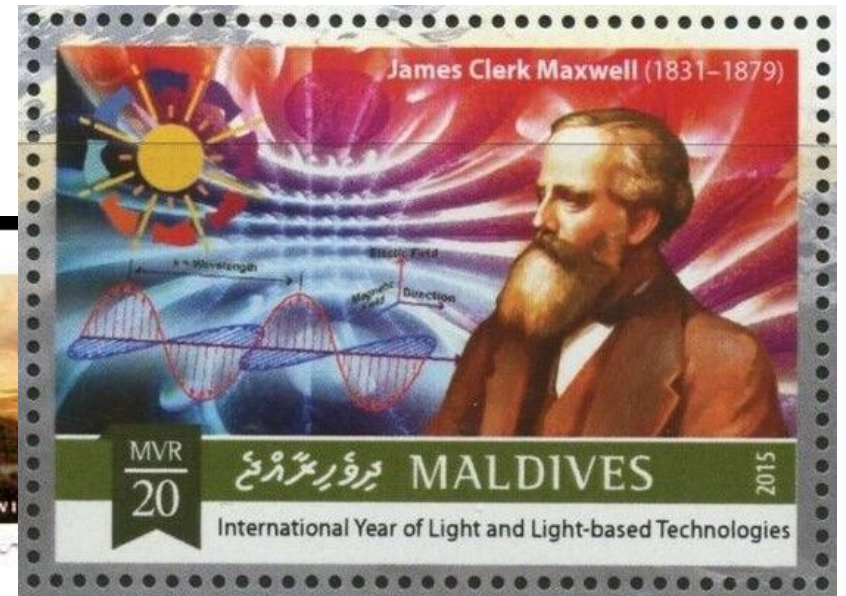
SOLAR STORM

THE CARRINGTON EVENT
AUGUST 28 THROUGH SEPTEMBER 2, 1859



TELEGRAPH SYSTEMS THROUGHOUT AMERICA AND EUROPE
FAILED, AND INTENSE AURORAL LIGHTS WERE WITNESSED
ACROSS THE NORTHERN HEMISPHERE, AROUND THE WORLD

The Carrington Event was a powerful geomagnetic solar storm which impacted Earth from August 28 through September 2, 1859. A solar coronal mass ejection aligned with and hit the Earth's magnetosphere inducing one of the largest known geomagnetic storms in recorded history. The associated "white light flare" in the Sun's photosphere had been observed by British astronomers Richard C. Carrington and Richard Hodgson. According to the experts, a solar storm of the same magnitude, if it were to occur today, would likely cause widespread disruption and chaos for our modern high-tech civilization. It has been predicted that there is a 12% chance of a similar event occurring through the year 2022.



**Magnetic &
electric fields**

**What relation
to solar storms
and auroras?**

**Earth-based
research →**

**Some balloons
& rockets →**

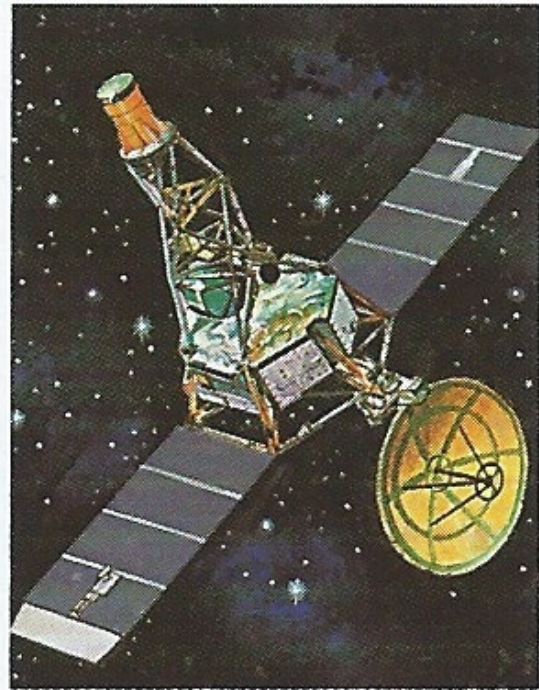
**IGY & Space
Age satellites**

The Space Age – A Great Leap Forward in Space Weather

Sputnik-1: begin the Space Age



СССР 1962



FEDERATED STATES
OF MICRONESIA

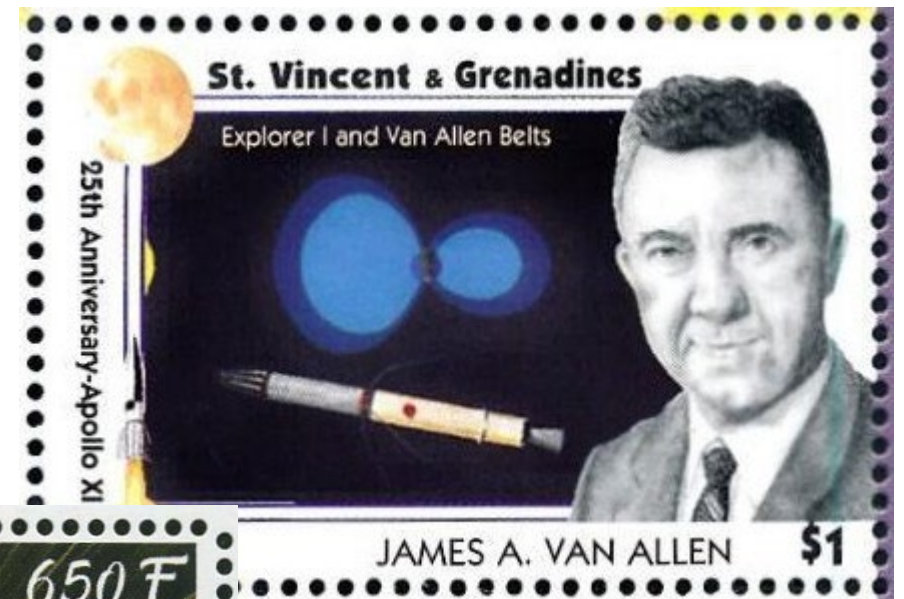
33¢

Mariner-2
discovers
the solar
wind in
1962



2019

République du Mali



Explorer-1
discovers
the Van
Allen
Radiation
Belts – 31
Jan, 1958)

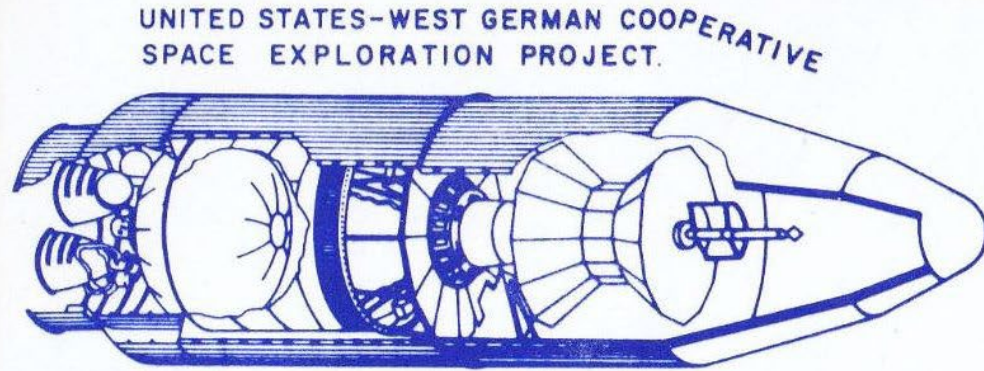
Solar Wind –
stream of
charged particles
from the Sun;
average 400 km/s
(1.5 million
km/h); ~4 days
Sun-Earth but can
be MUCH faster –
17 hr in the
Carrington event

The Magnetosphere



Helios-1 was launched in 1974, and OGO-4 in 1967

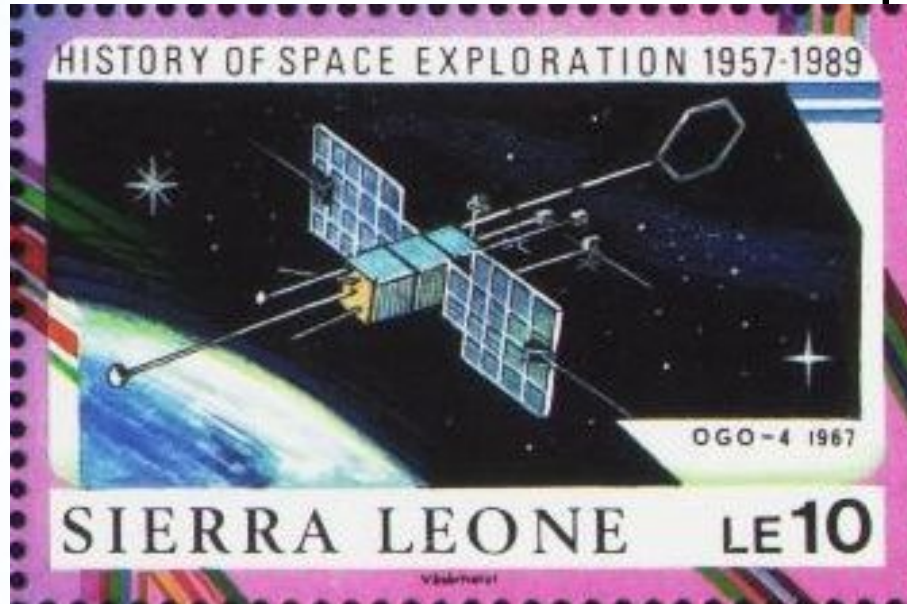
Solar storms → Energetic solar wind →
Complex interactions in the magnetosphere
among that solar wind & magnetic & electric
effects → geomagnetic storm → energetic
particles accelerated into polar regions →
Auroras



UNITED STATES-WEST GERMAN COOPERATIVE
SPACE EXPLORATION PROJECT.

MEASURES THE SOLAR WIND,
MAGNETIC AND ELECTRICAL FIELDS.

HELIOS-1
MADRID S.T.D.N.
TRACKING STATION



Auroral research – involves the study of high-energy solar particles in polar regions

e.g. by satellites such as ESRO-4 and Swedish Viking, and by research rockets

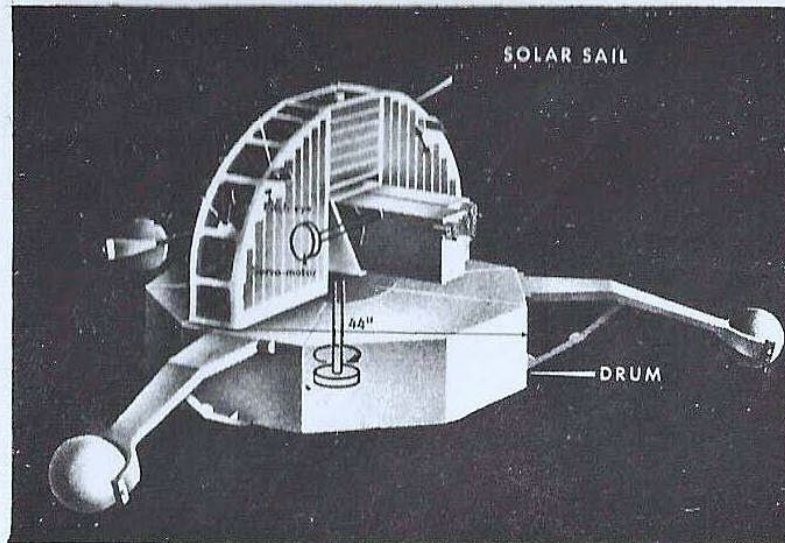
Auroral research rocket



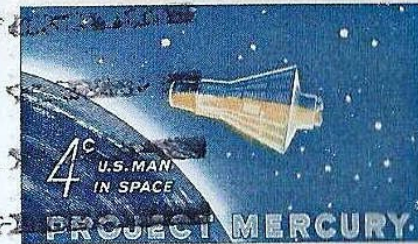
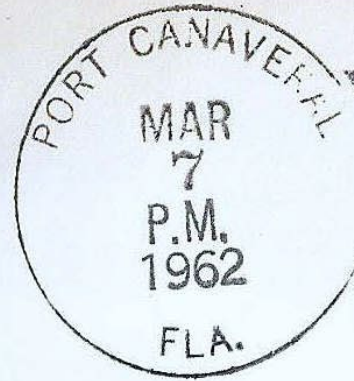
Swedish Viking satellite (launched in 1986)

OSO-1 – An Early Solar-Observing Satellite

OSO ORBITING SOLAR OBSERVATORY



TODAY LAUNCHED AT CANAVERAL ORBITING
SOLAR OBSERVATORY THE MOST COMPLEX
OBJECT LAUNCHED INTO SPACE SO FAR.

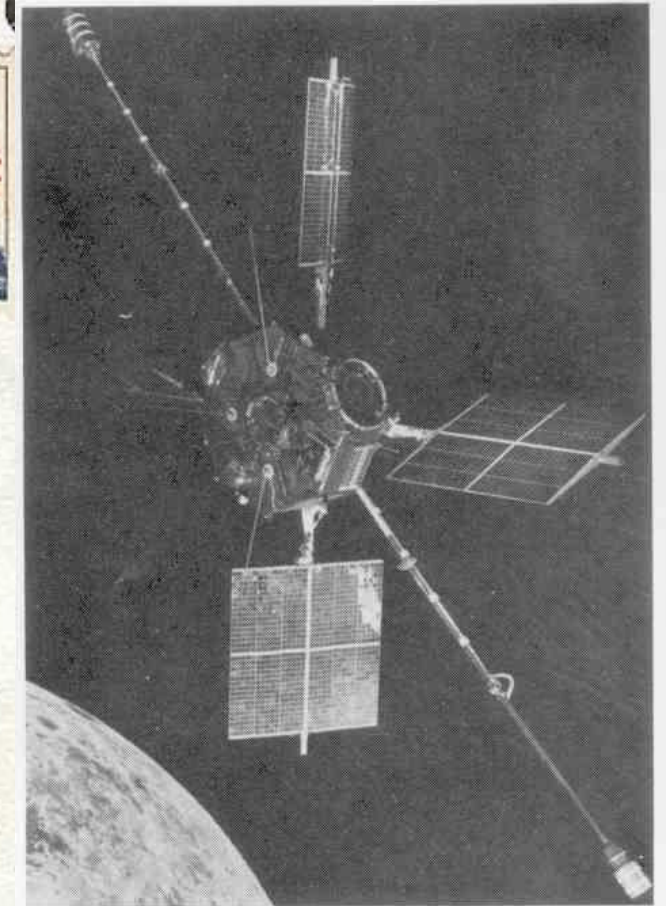


THE STORMY SURFACE OF THE SUN

Biological effect of space radiation levels – for Apollo program – Explorer-35



Explorer 35, launched in 1967, was one of 10 Interplanetary Monitoring Platforms that made notable discoveries about the solar wind and the Earth's magnetospheric tail. (NASA)

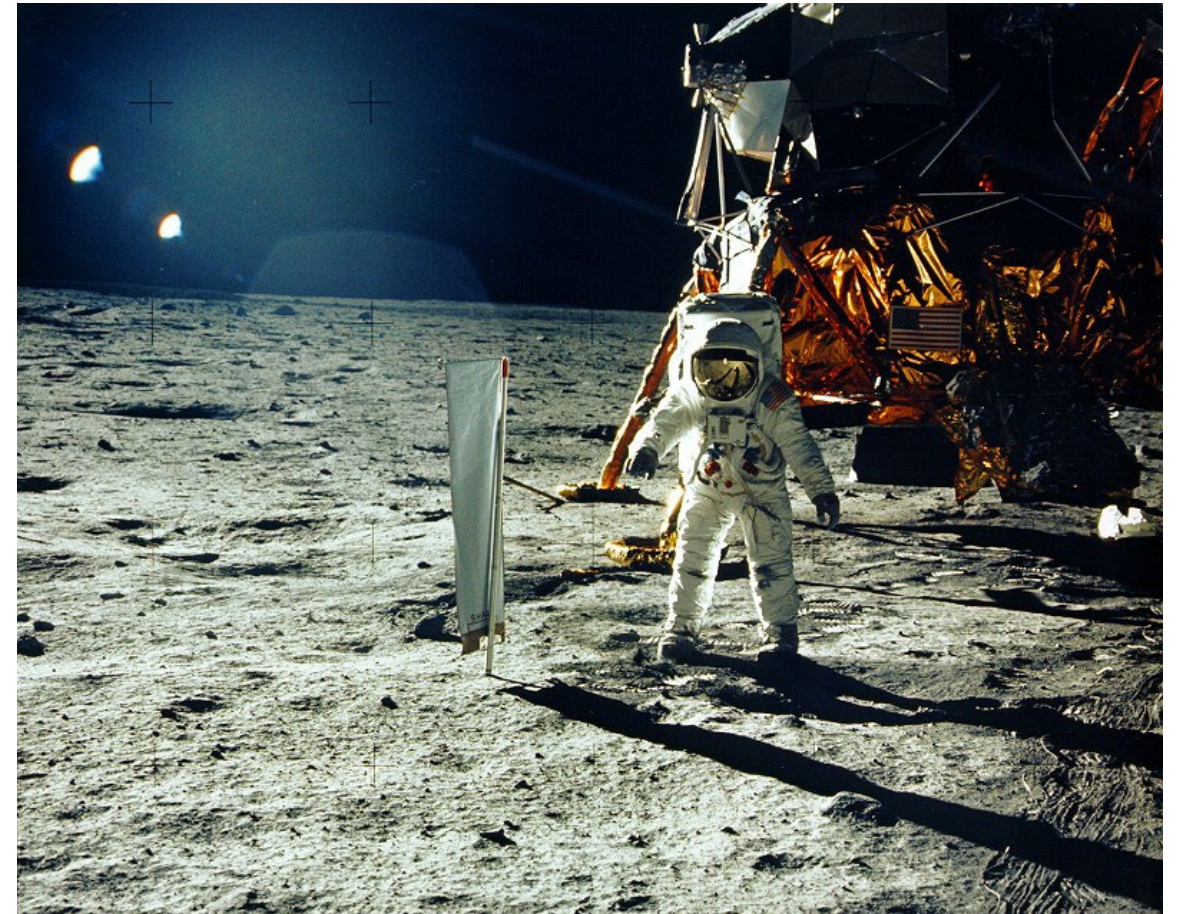


Solar Wind Composition Experiment (SWCE)

Buzz Aldrin beside the SWCE (Apollo-11)



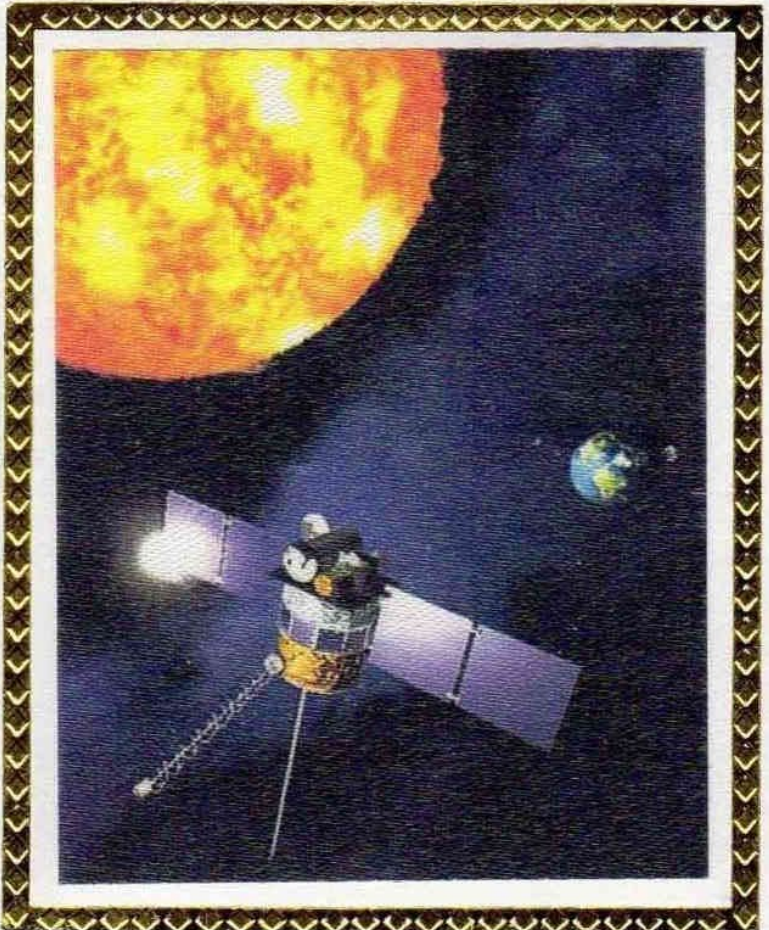
Stamp design based on this photo





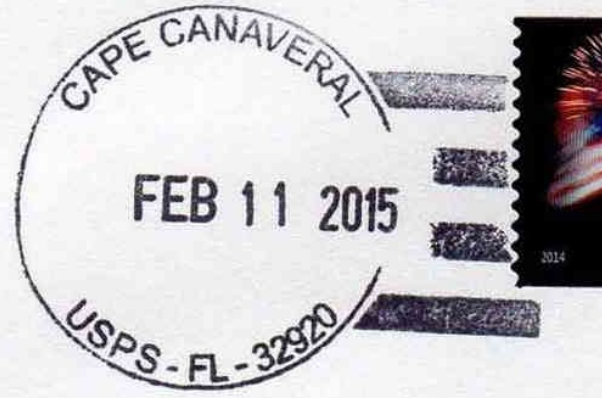
Two operational Solar & Space Weather Observing Satellites

DSCOVR



Colorano "Silk" Cachet

SOHO



DEEP SPACE CLIMATE OBSERVATORY (DSCOVR)
DSCOVR is the result of a partnership between NASA and the United States Air Force and will be used to observe and provide advanced warning of extreme solar emissions from the sun which can affect power grids, communications systems, and satellites close to Earth.

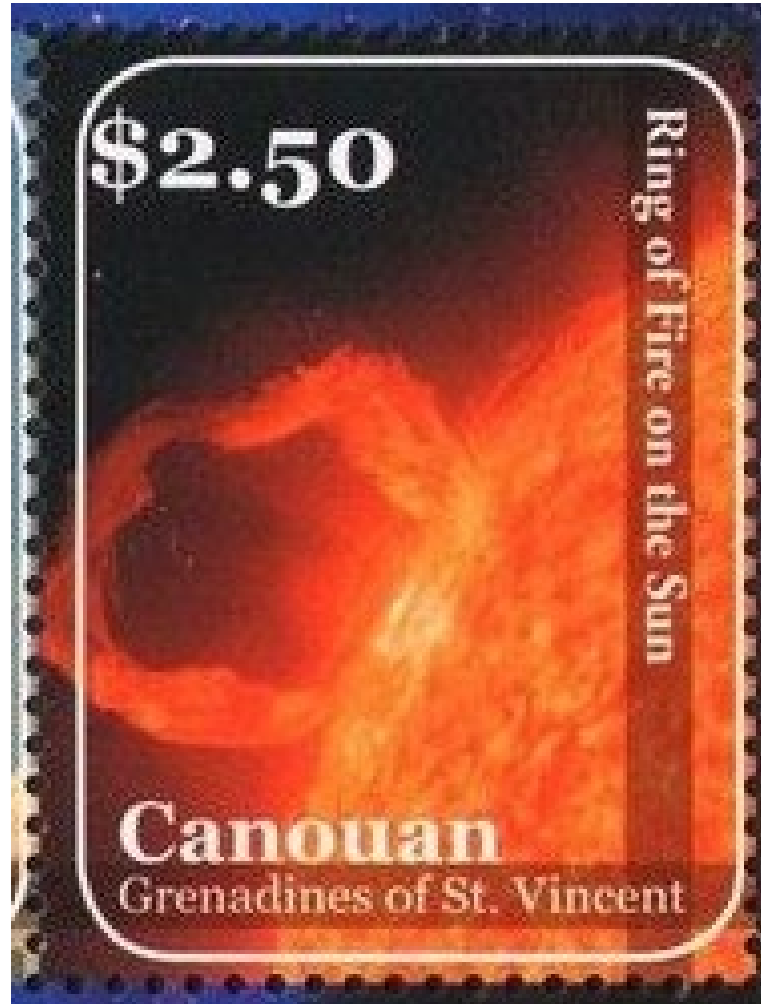


Solar Heliospheric Observatory

Major Space Weather Storms – and Impacts



Solar Flares



CMEs (Coronal Mass Ejections)

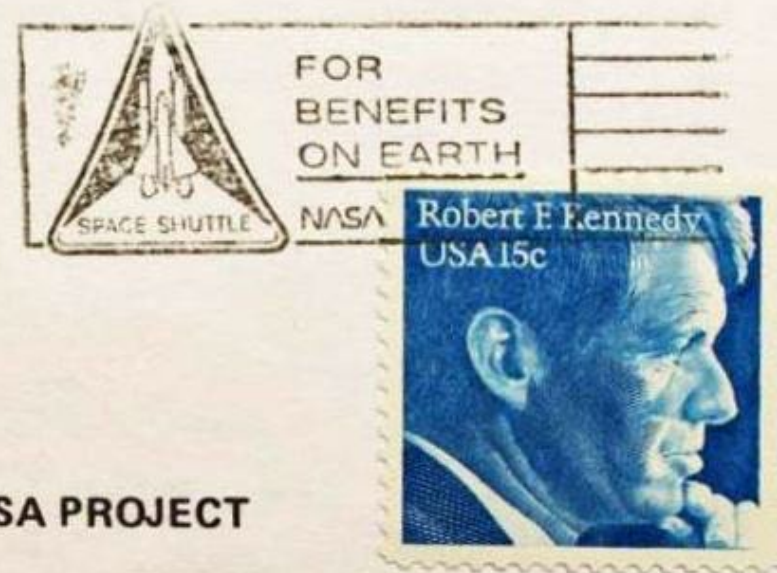
- Biological
- Telecommunications
- Aviation (ATC, nav aids, landing aids)
- Navigation (e.g. 13 Dec 2006 – GPS outage on sunlit side of Earth)
- Power grids (e.g. QC 13 Mar 1989)
- Satellites (anomalies, damage and even loss, or orbital decay)
- Auroras

Impacts - Damage to Satellites due to Electrical Charging and Static Effects

SPACECRAFT
CHARGING AT
HIGH ALTITUDE



*Launched by Delta 148
Complex 17-CCAFS
Jan. 30, 1979-4:42 p.m. EST*



JOINT AIR FORCE/NASA PROJECT

Managed by the Air Force Space Test
Program Directorate, SAMSO.

Spacecraft designed to find solutions to the
problem of "Static Charging" which has
damaged previous satellites.

Impacts - Ionospheric effects (radio transmission and communications)



Impacts - Loss of Satellites due to Atmospheric Density Effects

SpaceX to lose as many as 40 Starlink satellites due to space storm

PUBLISHED WED, FEB 9 2022 10:53 AM EST | UPDATED WED, FEB 9 2022 6:42 PM EST



Michael Sheetz
@THESHEETZTWEETZ

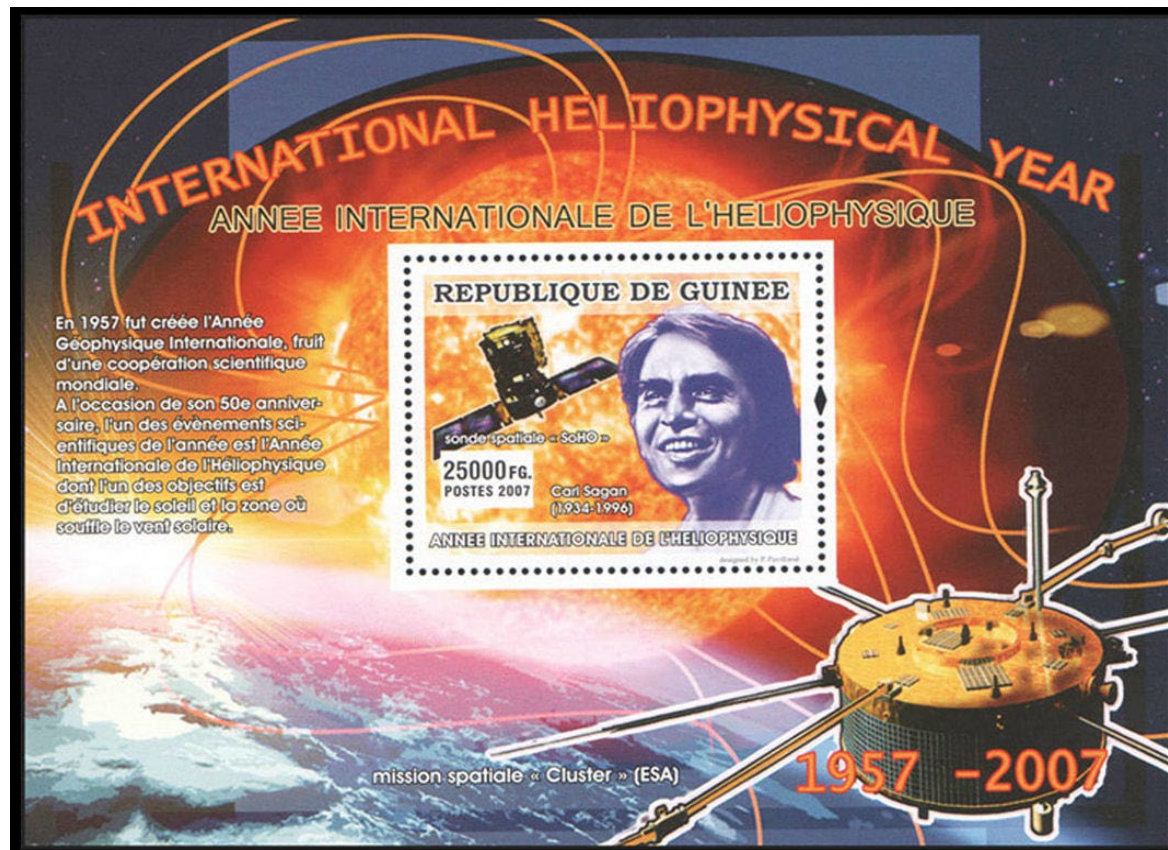
KEY POINTS

- Elon Musk's SpaceX expects to lose nearly an entire launch's worth of Starlink satellites after a storm created by the sun struck the Earth's atmosphere.
- The company launched 49 Starlink satellites on Feb. 3, but "up to 40 of the satellites" will be lost due to this geomagnetic storm.
- SpaceX does not disclose the exact cost of its Starlink satellites or its Falcon 9 launches – but losing the majority of the mission could be a financial hit upward of \$50 million, based on previous statements from company leadership.

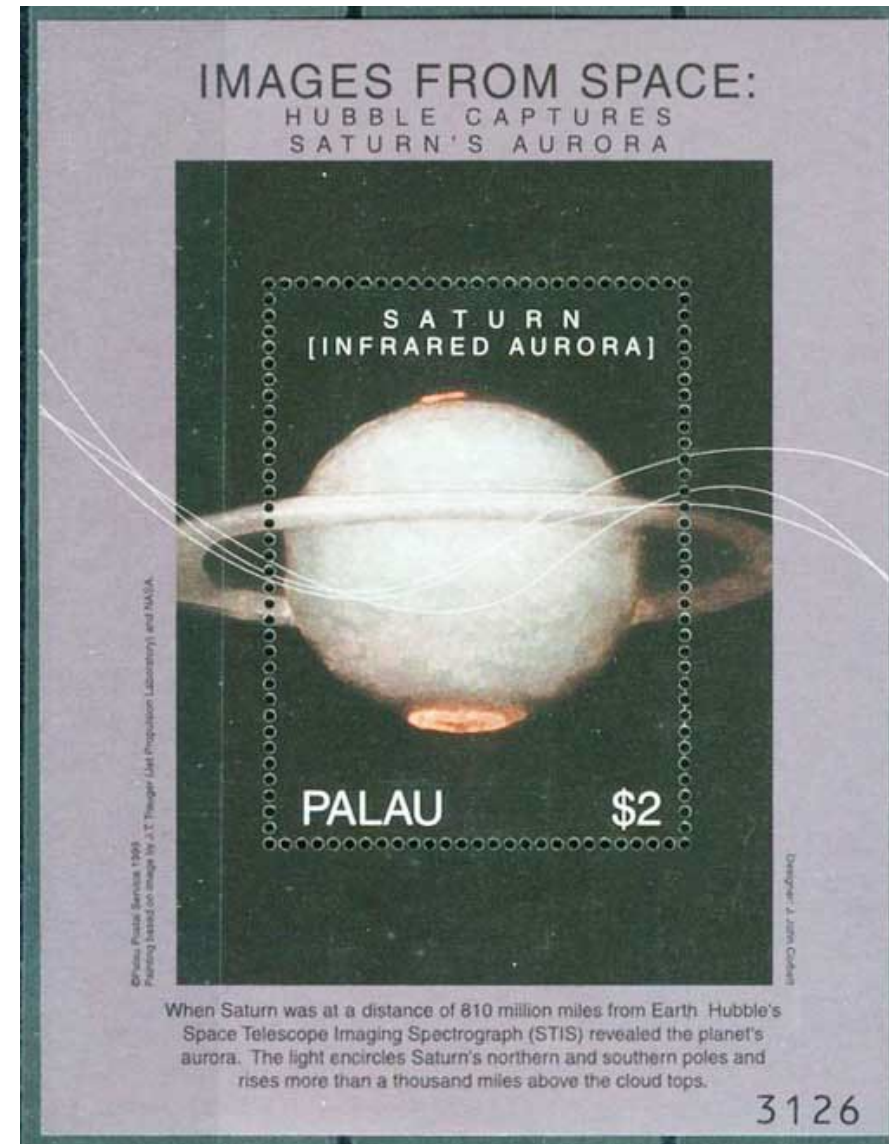


Closing Space Weather Stamp Images

IHY (2007)



Saturn aurora





Hillger & Toth Weather and Climate Philately website

<https://rammb.cira.colostate.edu/dev/hillger/index.html>



Collective Philatelic Works (of Two Meteorologists)



This page has links to the collective philatelic works (in the topic areas below) of two meteorologists, **Don Hillger** (USA) and **Garry Toth** (Canada). Our goal, since 2001, has been to build an online catalog of topics of interest to the authors, to make it available to, and shared with anyone interested. This is a work in progress, and completeness is our goal, except where specific exceptions are noted. If readers know of additional information or images in these areas, please contact the authors using the e-mail addresses in the link at the bottom of this page.

Collective Philatelic Works (of Two Meteorologists)		
		<u>Weather and Climate Philately</u>
		<u>Un-Manned Satellite Philately</u>

The Philately of Space Weather – Toth & Hillger references

1. Web page <https://rammb.cira.colostate.edu/dev/hillger/space-wx.htm>

2. **Space Weather Handbook** (Toth and Hillger) available through the ATA as **Handbook 166E**, or in **DVD** format

166 - Space Weather - A Philatelic Journey - Print Edition



\$65.00

\$60.00 - Member price

Qty: - 1 +
3 in stock

Add to cart [View cart](#)

<https://www.swpc.noaa.gov>



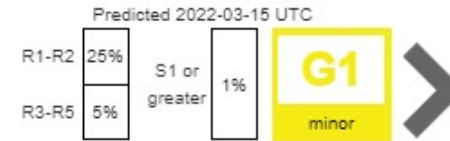
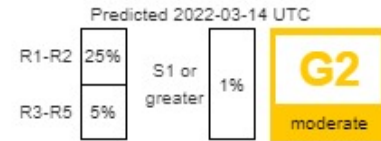
SPACE WEATHER PREDICTION CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Monday, March 14, 2022 05:35:05 UTC

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FEEDBACK

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SPACE WEATHER CONDITIONS on NOAA Scales



Solar Wind Speed: **428** km/sec

Solar Wind Magnetic Fields: Bt **24** nT, Bz **22** nT

Noon 10.7cm Radio Flux: **123** sfu

G2

MODERATE Geomagnetic Storm **WATCH:**
14 March, 2022 UTC-day. G1 (Minor) Watch out for 15 March.

G2 Storm Observed

published: Sunday, March 13, 2022 17:03 UTC
A G2 (Moderate) level geomagnetic storm was observed at 8:51 a.m. ET.

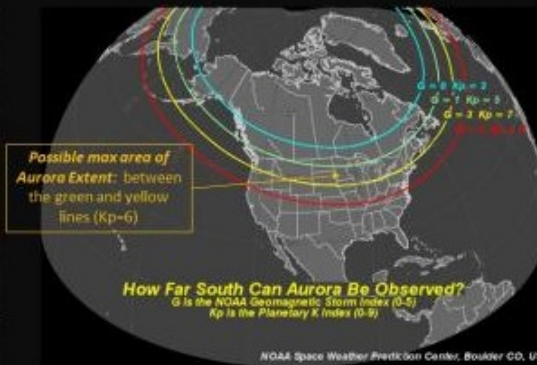
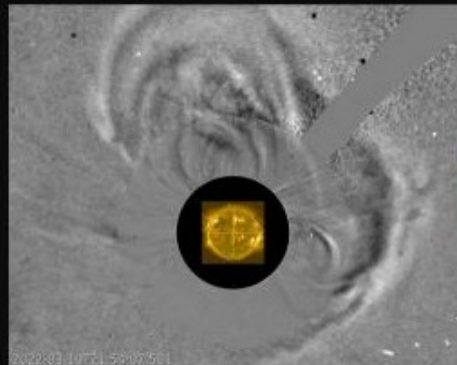
G1-G2 (Minor-Moderate) Watch for 14-15 March 2022

published: Sunday, March 13, 2022 04:36 UTC
A G2 (Moderate) geomagnetic storm watch has been issued for 14 March (UTC day) and a G1 (Minor) watch is out for 15 March due to possible effects f

Geoelectric Field Map Update to 3D empirical conductivity model

published: Tuesday, March 08, 2022 15:24 UTC
The Space Weather Prediction Center is pleased to announce the operational release of *updated* geoelectric

Planned - System Testing and Maintenance 08 March 2022



NOAA Space Weather Prediction Center, Boulder CO, US



End

**Thanks for listening.
Questions?**

